Review of "Low cloud reduction within the smoky marine boundary layer and the diurnal cycle" by J. Zhang and P. Zuidema

This manuscript presents a characterization of smoky and non-smoky boundary layer (BL) structures and their diurnal cycle over the Ascension Island. Measurements from the years 2016 and 2017 show that high levels of smoke frequently are observed in the BL in the month of August. Simultaneously, the observed BL is warmer and deeper and the cloud fraction is lower. The authors argue that there is a causal relationship between the increased amounts of smoke and the lower cloud cover fraction and suggest a potential mechanism.

The presented observations of the BL over the Ascension Island are interesting and highly relevant for the scientific community. However, I find several issues with the manuscript in its current form. Firstly, and most importantly, the suggested causal relation between the enhanced smoke levels and cloud fraction is speculative and not necessarily supported by the observations. The causal relation is an hypothesis and should be presented as such. In fact, I find that relationship could very well work in the other direction: that it is the BL structure, cloudiness and exchange with the free troposphere that results in enhanced levels of smoke in the BL. The authors should at least consider this potential explanation. Secondly, the overall message, structure and clearness of the manuscript could be substantially improved.

Main comments:

- Throughout the manuscript, it is assumed that elevated BC concentrations *cause* certain changes in cloud cover, precipitation, temperature, BL structure etc. But in most (all?) cases the relation could very well be the opposite. For example, in Figure 7, it seems to me that the blue curves (in particular for 2016) show a diurnal variation in cloud fraction typical for a Sc deck while the red curves are more typical for a situation with Sc to Cu transition (cf. e.g. the review on stratocumulus by Wood, 2012). Could it not be that the overall large-scale meteorological conditions during certain periods are more favorable for Sc to Cu transition and afternoon Cu formation, i.e. that the subsidence is weaker? This would also favor a weaker inversion and more mixing of free tropospheric (polluted) air into the BL. Other examples:
    - Page 7, lines 5-6: "A boundary-layer semi-direct effect is clear: when more smoke is present in the boundary layer, the diurnal-mean low-cloud cover decreases." To me, the relationship could very well work the other way.
    - Page 7, lines 21-22: "The presence of more smoke reduces how frequently rain reaches the surface, although a slight late-night maximum and secondary late-afternoon maximum is still present." Rain could also decrease the smoke concentrations.
    - Page 8, lines 21-24: "Diurnally-resolved mean thermodynamic profiles indicate that the deepening of the smokier boundary layers occurs during the morning, followed by more significant shoaling during the night (Fig. 12a). The potential temperature of the smokier composite is the most warm near the surface in the mid-afternoon (14 LST), with the warmth moving upward in the late afternoon (17 LST)." What is the cause and the effect here?
    - Page 8-9, lines 30 and 1-2: "The warming is greater near the surface than higher in the boundary layer, which suggests that the absorbing aerosol may be preferentially located near the surface." Alternatively, the surface is just warmer in these cases.

- Related to the comment above, I miss a discussion on the general BL structure in the region and its diurnal variation. What would be the typical BL variation (and large-scale situation) for a day with thick stratocumulus clouds and a day with more stratocumulus above cumulus? It appears to me that in non-smoky conditions, the surface layer is stably stratified during night. In smoky conditions, it stays relatively well mixed (Fig 12). Could this indicate more mixing from above for the smoky conditions?
- Statistical significance, usage of "similar", "different", "clearly less" etc. and general uncertainties: There are in total 13 smoky days and 13 less-smoky days, how robust are the conclusions that you draw from this number of cases? Some examples:
    - Page 7, lines 13-14: "The LWP is clearly less in the afternoon under smokier conditions in 2016, though not so in 2017." Compared to what? And is the difference robust/statistically significant? How many samples do you have in each bin?
    - Page 7, lines 14-15: "A more consistent feature between the two years is the reduction in LWP apparent after midnight in smokier conditions. Also consistent is an atypical increase in LWP that occurs mid-morning, after the cloud cover has begun to decline." Are these differences/variations significant?
    - Figures 8c&d and 9: what is the standard deviation for the different curves? Can you say with confidence that "Clouds are fewer and may be less vertically-developed in smokier boundary layers" and "… cloud tops are higher in the morning (06 – 12 LST) under smokier conditions…"?
    - Figure 13 and the discussion on page 9: what is the standard deviation? "The sub-cloud RH decreases during the day for higher smoke loadings…" but this occurs also for low smoke conditions? And is this decrease really robust? Same with "…with both peaking around 20 LST for light smoke loadings, and several hours later, around 2 am LST, for heavier smoke loadings." Is this really a robust variation?
- Sections 5, 6 and 8: I am not sure these sections add much information. In general, I found them too speculative and did therefore not comment them in detail. In Figure 17, I would say that the differences are not significant.
- Section 7: This section could be extended and written more carefully. For example:
    - "Most fire emissions occur on the African plateau, ~1000 meters above sea level, with isentropic flow initially placing the biomass burning aerosols outflow above the low cloud deck. " How often does this happen? And how would this influence your results/conclusions?
    - "Comprehensive visual inspection of the one-minute micropulse lidar extinction and depolarization profiles indicates that elevated smoke plume are frequent above Ascension in August." How often? This type of statistics would be highly relevant to show.

Minor comments (on the sections I read in more detail):

Abstract:

- Line 3: "… recent observations…", specify when.
- Line 13: "…. increase…" compared to what?
- Line 21: "…more easterly…" compared to what?

1. Introduction

- I find the structure with unpublished figures in the introduction strange. I would recommend to include these figures (and the associated discussion) in Section 2 instead, as a part of the overview.

- I miss some general question/questions stated at the end of the introduction.
- Line 6: "…stratocumulus thickening can occur…"
- Line 19: "This type of marine…"
- Line 17: What do you mean with "The diurnal time scale is faster than that of meteorology…"?

2. Data, overview and compositing approach

- Page 4, line 5: What do you mean with "additional cloud"?
- Page 4, line 22: Define abbreviation (rBC).
- Page 5, lines 3-4: What do you mean with "perhaps through their enclosure"?
- Page 5, line 23: How do you know that the retrieved LWPs include only Sc and shallow Cu?
- Page 6, line 14: "…indicate remarkably similar conditions…" Similar in terms of what? Cloud cover? rBC? CO? or all? And how do you define "similar"?
- Page 6, lines 16-17: "The exception is 21-23 August of 2017, when CO concentrations are close to the background value and rBC mass concentrations are…" What about 2016, 1-6 and 24-27?
- Page 6, line 19: "lasting for just a little shy of a week." Are you talking about 2016 or 2017?
- Page 6, line 21: "…clearly reduces this time…" compared to what?

3. The cloud diurnal cycle as a function of the smoke loading

- Page 7, lines 31-32: what do you mean with "…when they correlate more strongly with lower cloud fractions…"?

4. Explanations for the altered cloud diurnal cycle

- Page 8, lines 5-6: "The radiosonde thermodynamic profiles (Fig. 11) indicate boundary layer depths that can exceed the cloud top heights documented in Fig. 10." But you don't see all cloud tops in Figure 10?
- Page 8, lines 7-8: "The deepening of the boundary layer is more well-defined…" compared to what?
- Page 8, line 28: I would suggest to change "fluxing" to "flux".
- Page 9, lines 5-6: Days with daily rBC variation less than 120 ng m-3 and 50 ng m-3, respectively, are selected from the "more" and "less" smoky days, and detrended. Please clarify.
- Page 10, line 10: "Under smokier conditions, the near-surface rBC values accumulate after mid-night.". This difference do not seem robust.
- Page 10, lines 12-13: "Overall, during a typical day, smoke settles towards the surface under smokier conditions, and is advected upwards when the surface layer is less smoky". This formulation is unclear to me.

5. Examples

- Page 10, lines 20-21: "…indicate cumulus clusters in the morning…" or cumulus under stratocumulus?
- Page 10, line 22: What do you mean with "upper level cloud"?
- Figure 15: what is RF in the figure? And what does the KAZR radar mainly see? I assume it is mostly precip-sized particles, this should be clarified.
- Page 10, line 23: "…with only scattered cumuliform clouds remaining…" How do you see this? And are you talking about both cases?

References

Wood, R. 2012. REVIEW: Stratocumulus Clouds. Monthly Weather Review, 140, 2373-2421.